PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Means for Cooling the Cabins of Aircraft or other Spaces

We, GODFREY (HANWORTH) LIMITED, formerly Sir George Godfrey and Partners (Holdings) Limited, a Company organised under the laws of Great Britain, of Hampton Road, Hanworth, Middlesex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to means for cooling the cabins of aircraft or other spaces. Cabin temperatures sometimes become unbearably high in a standing aircraft, for example, when the aircraft is on a tropical aerodrome. Even when the aircraft is at rest under temperate conditions some measure of cooling is often necessary for the comfort of the occupants of the cabin. It is therefore desirable to have facilities at aerodromes for cooling the cabins of aircraft when standing and the present invention provides means for this purpose and which may also be employed, of course, for other appropriate space-cooling applications.

Means have already been proposed for cooling mine workings which comprise a truck having mounted thereon a compressor to receive air from the mine atmosphere, an evaporator arranged to be heated by the hot compressed air delivered by the compressor, means to lead away steam from the evaporator, and an expansion motor coupled to the compressor and receiving compressed air passed from the evaporator, the expansion motor receiving an additional supply of compressed air from the mine installation such that the total flow through the expansion motor drives the compressor.

According to the present invention means for cooling the cabins of aircraft or other spaces are provided in the form of a vehicle capable of being moved into and out of proximity to the aircraft cabin or other space to be cooled, said vehicle comprising a prime mover, an air compressor driven from said prime mover, an expander, means providing a channel along which compressed air from the compressor is delivered through an intercooler to the expander and further means capable of detachable connection to the aircraft cabin or other space to provide a channel thereto from the expander, air entering the compressor undergoing the process of compression, intercooling and expansion thereby leaving the expander in a cooled state in which it is delivered to the aircraft cabin or other space to be cooled.

The air compressor, expander and prime mover are preferably all coupled in positive driving relationship, the drive from the prime mover to the compressor and expander being either direct or through the intermediary of increased speed gearing. In one arrangement a centrifugal compressor is employed in conjunction with an expander in the form of a turbine mounted on the same shaft as the compressor, such shaft being driven from the crankshaft of a piston engine through gearing which enables the coupled expansion turbine and centrifugal compressor to be driven at appropriately higher revolutions than the engine crankshaft.

In order to enable efficient employment of the compressor and expander it is necessary that the air delivered by the compressor should be cooled before expansion over the turbine with further loss of heat and to this end a heat exchanger is arranged between the delivery side of the compressor and the turbine entry to function as the intercooler for the throughput air. The capacity of the compressor is preferably more than sufficient for turbine requirements to enable a portion of the compressor delivery to be tapped and passed through a heat exchange utilising the exhaust heat of the engine whereafter it is delivered to a turbine which may be arranged to drive means for causing cooling air to flow through the intercooler.

If desired in the channel between the delivery side of the compressor and the intercooler valve means may be provided which

[*Price 3s. 6d.*]

are operable to provide a restricted flow path from the compressor to a branch channel through which the air delivered by the compressor is caused to flow so that the compressor does increased work on the air and provides a supply of hot air for heating purposes, as described in the specification of our co-pending application for Letters Patent No. 20069/51 (Serial No. 771,736). The provision of this heating choke renders the apparatus suitable for heating the cabin of an aircraft when the latter is standing at temperatures below freezing point, for example at arctic airfields, or for other space-heating applications, the branch channel being adapted to receive means capable of detachable connection to the aircraft cabin or other space, as in the case of the delivery side of the expander.

The heating choke may be adjustable to enable the compressor delivery to be variably throttled in order to afford the desired degree of heating. Moreover valve means may be provided to isolate the expander from the compressor delivery without bringing the heating choke into operation whereby a supply of pressure air at ordinary temperatures is available from the compressor for the purpose of pressure testing the cabin of the aircraft and enabling safety checks to be made on the valves and general airworthiness of the pressure cabin.

If desired, means may also be provided for injecting liquid disinfectant or deodorant material into the air entering the compressor to enable the cabin to be fumigated or deodorised. This anti-pest or deodorant injection is of particular benefit when the aircraft is standing at an aerodrome in the tropics.

A preferred embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings in which:—

Figure 1 is a perspective view of the vehicle embodying the cooling, heating and pressure testing system, this figure also showing a portion of a hosepipe by which the system can be detachably connected to the aircraft cabin or other space, and

Figure 2 is a diagrammatic representation of the prime mover, compressor and expander of the cooling, heating and pressure testing system embodied in the truck shown in Figure 1.

Referring to the drawings, the cooling means are constructed as a truck 10 capable of being driven or drawn across the aerodrome to a position adjacent the cabin of a standing aircraft where it forms a self-contained unit capable of supplying all the aforementioned cabin air-conditioning services. In the example illustrated the truck 10 is constructed as a trailer vehicle provided with wheels 11, a drawbar 12 being provided to enable the truck to be drawn across the aerodrome to the aircraft by means of a tractor or the like.

The prime mover is in the form of an internal combustion engine 13 of the piston type, shown in Figure 2, mounted on the chassis 10*a* of the truck with its crankshaft arranged longitudinally thereof, such crankshaft driving through increased speed gearing contained within a gearbox 14 a centrifugal compressor 15 mounted on a shaft 16 which is also arranged longitudinally of the truck chassis 10*a*.

Arranged coaxially of the centrifugal compressor 15 and coupled thereto by means of the common shaft 16 is an inward flow turbine 17, air delivered by the compressor passing long ducting to the turbine over which is is expanded with extraction of heat therefrom. Ducts 18, 19 convey the air from the compressor to an air-to-air heat exchanger operating as an intercooler 20 for the throughput air which is accordingly cooled after leaving the compressor and before passing through a duct 21 to the turbine 17 where further heat is extracted whereafter it is delivered through the outlet 22 of the turbine which forms a cold air delivery pipe. Detachably coupled to the outlet 22 is a flexible hose 23 the other end of which is provided with coupling means to enable it to be connected to a nozzle leading to the aircraft cabin. Preferably the heat-exchanger 20 is arranged in the roof of the truck 10 as illustrated in Figure 1.

The truck also carries a fuel supply for the engine 13 so that the vehicle is enabled to operate as a complete self-contained unit, as already mentioned, when it is brought into juxtaposition with the aircraft. In order to enable utilisation of the exhaust heat of the engine 13 the exhaust is passed through an exhaust pipe 24 to a turbine 25. The disc of this exhaust heat turbine is mounted on a shaft 26 which also carries a fan 27 operating to induce atmospheric air through the intercooler 20 arranged between the compressor 15 and turbine 17 of the apparatus. Alternatively the compressor 15 may be made of somewhat larger capacity than is required for cooling air requirements so that a portion of its delivery may be tapped and passed to an exhaust heat exchanger, the air from the compressor being thereby heated before delivery to the turbine 25 driving the fan 27. The capacity of the compressor may be such that the efficiency of the air cycle cooling means is not affected by this arrangement.

In the embodiment illustrated, air at the ambient temperature of the aerodrome is drawn either through the radiator 28 of the engine 13 by means of a fan 29 driven by the latter and arranged in a casing 30 or through the inlet 31*a* of a valve 31 arranged rearwardly of the casing. From such valve the air passes through a duct 31*b* in which a filter 32 and a silencer 33 are arranged through which the air passes before entering the compressor 15, a further silencer 34 being

preferably arranged immediately after the latter. From the delivery silencer 34 the compressed air passes along the ducts 18, 19 to the fan-cooled intercooler 20, which removes at least part of the heat generated due to the compression of the air, and thence to the expansion turbine 17 in which further heat is removed from the air stream which passes therefrom through the cold air delivery pipe 23.

From the duct 18 between the compressor 15 and the intercooler 20 a branch channel 35 leads which is closed when the apparatus is being operated to supply cooling air. This branch channel 35 is provided with valve means in the form of a two-way valve 36 operable to close the duct 19 to the intercooler 20 and open the branch channel which is provided with adjustable restriction valve means 37 operable to form a choke so that the air delivered from the compressor 15 and passing therealong is heated to form a source of heated air for cabin-heating purposes when an aircraft is standing on an arctic airfield. As already described in relation to the cooled air supply, the heated air may be supplied to the aircraft cabin through a hosepipe, not illustrated, fitted to the end 35*a* of the branch channel. A further branch channel 38 on the opposite side of the intercooler 20 may be arranged with suitable valve means 45 enabling the turbine 17 to be isolated from the compressor delivery, the channel thereby providing a source of pressurising air at moderate temperature to enable safety checks to be made on the valves of the pressure cabins of high altitude aircraft. a pressure relief valve 39 being provided which is set at the rated pressure when pressure testing.

It will be appreciated that, when the apparatus is being operated to supply cooling air, the supply of air is drawn directly from atmosphere through the inlet 31*a* of the valve 31. When heated air is required the valve 31 is operated so that the supply of air is drawn through the radiator 28. A clutch 40 is provided on the shaft 26 so that the fan 27 of the intercooler 20 can be uncoupled from the turbine 25 when warmed air is required. Hinged caps 41,42,43 are provided to blank off the open ends of the ducts 35, 38 and the turbine outlet 22 respectively, such caps being selectively opened to allow a flexible hosepipe to be secured to the end of the duct required and thus forming valve means controlling the air flow in the apparatus.

If desired the chassis 10*a* of the truck may comprise longitudinal members connected by cross members, a body of light sheet metal being provided to enclose the various machines. Preferably the engine 13, its radiator 28 and the compressor 15 are arranged in an insulated tunnel, not illustrated, with the radiator fan 29 drawing air through louvres 44 in the front of the truck body, this arrangement enabling the segregation of these elements in order to prevent undue loss of cooling efficiency through radiation of heat therefrom to the intercooler 20 and expansion turbine 17.

What we claim is: —

1. Means for cooling the cabins of aircraft or other spaces in the form of a vehicle capable of being moved into and out of proximity to the aircraft cabin or other space to be cooled, said vehicle comprising a prime mover, an air compressor driven from said prime mover, an expander, means providing a channel along which compressed air from the compressor is delivered through an intercooler to the expander and further means capable of detachable connection to the aircraft cabin or other space to provide a channel thereto from the expander, air entering the compressor undergoing the process of compression, intercooling and expansion thereby leaving the expander in a cooled state in which it is delivered to the aircraft cabin or other space to be cooled.

2. Means according to claim 1, wherein the air compressor, expander and prime mover are all coupled in positive driving relationship, the drive from the prime mover to the compressor and expander being either direct or through the intermediary of increased speed gearing.

3. Means according to claim 1 or 2, wherein a centrifugal compressor is employed in conjunction with an expander in the form of a turbine mounted on the same shaft as the compressor, such shaft being driven from the crankshaft of an internal combustion engine through gearing which enables the coupled expansion turbine and centrifugal compressor to be driven at appropriately high revolutions than the engine.

4. Means according to any of the preceding claims, wherein a heat-exchange is arranged between the delivery side of the compressor and the expander entry to function as the intercooler for the throughput air.

5. Means according to claim 4, wherein valve means are provided in a channel or duct between the delivery side of the compressor and the intercooler to form a heating choke and are operable to provide a restricted flow path from the compressor to a branch channel through which the air delivered by the compressor is caused to flow so that the compressor does increased work on the air and provides a supply of hot air for heating purposes, the branch channel being adapted to receive means capable of detachable connection to the aircraft cabin or other space.

6. Means according to claim 5, wherein the heating choke is adjustable to enable the compressor delivery to be variably throttled in order to provide the desired degree of heating.

7. Means according to claim 5 or 6, wherein

valve means are provided wich are operable to isolate the expander from the compressor delivery without bringing the heating choke into operation whereby a supply of pressure air at ordinary temperatures is available from the compressor for the purpose of pressure testing the cabin of the aircraft.

8. Means according to any of claims 4 to 7, wherein the intercooler is an air-to-air heat exchanger cooled by means of a fan.

9. Means according to any of the preceding claims, wherein valve means are provided on the inlet side of the compressor which permit air to be drawn into the latter either directly from the ambient atmosphere or alternatively permit air to be drawn into the compressor through a radiator employed for cooling the prime mover.

10. Means according to claim 7, wherein a branch channel or duct is arranged between the intercooler and the expander to form a delivery channel for the air for pressure testing, pressure relief valve means being provided in such channel.

11. Means according to claims 3 and 8, wherein a turbine driven by the exhaust of the engine is coupled to and drives the fan of the intercooler, a clutch being arranged between the turbine and the fan to enable the latter to be uncoupled from the turbine when warm air is required to be delivered.

12. Means according to any of the preceding claims, wherein the means forming a detachable connection to the aircraft cabin or other space comprises a detachable flexible hosepipe by which the hot air, cold air, and air at ordinary temperature is conveyed to the space to be heated, cooled or pressure tested, hinged caps being provided at the ends of the respective channels along which such air passes which form stop valves which are opened for the attachment of said flexible hosepipe.

13. Means according to any of the preceding claims, wherein said vehicle is in the form of a trailer provided with wheels and having a body which encloses the prime mover, compressor and expander.

14. Means for cooling the cabins of aircraft or other spaces substantially as herein described with reference to the accompanying drawings.

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PROVISIONAL SPECIFICATION

Means for Cooling the Cabins of Aircraft or other Spaces

We, SIR GEORGE GODFREY AND PARTNERS (HOLDINGS) LIMITED, a Company organised under the laws of Great Britain, of Hampton Road, Hanworth, Middlesex, do hereby declare this invention to be described in the following statement:—

This invention relates to means for cooling the cabins of aircraft or other spaces. Cabin temperatures sometimes become unbearably high in a standing aircraft, for example, when the aircraft is on a tropical aerodrome. Even when the aircraft is at rest under temperate conditions some measure of cooling is often necessary for the comfort of the occupants of the cabin. It is therefore desirable to have facilities at aerodromes for cooling the cabins of aircraft when standing and the present invention provides means for this purpose and which may also be employed, of course, for other appropriate space-cooling applications.

According to the invention means for cooling the cabins of aircraft or other spaces are provided in the form of a vehicle capable of being moved into and out of proximity to the aircraft cabin or other space to be cooled, said vehicle comprising a prime mover, an air compressor driven from said prime mover, an expander, means providing a channel along which compressed air from the compressor is delivered to the expander and further means capable of detachable connection to the aircraft or other structure to provide a channel thereto from the expander, air entering the compressor undergoing the reversed heat cycle and leaving the expander in a cooled state in which it is delivered to the aircraft cabin or other space to be cooled.

The air compressor, expander and prime mover are preferably all coupled in positive driving relationship, the drive from the prime mover to the compressor and expander being either direct or through the intermediary of increased speed gearing. In one arrangement a centrifugal compressor is employed in conjunction with an expander in the form of a turbine mounted on the same shaft as the compressor, such shaft being driven from the crankshaft of a piston engine through gearing which enables the coupled expansion turbine and centrifugal compressor to be driven at appropriately higher revolutions then the engine crankshaft.

In order to enable efficient employment of the air cycle principle it is necessary that the air delivered by the compressor should be cooled before expansion over the turbine with further loss of heat and to this end a heat exchanger is preferably arranged between the delivery side of the compressor and the turbine entry to function as an intercooler for the throughput air. The capacity of the compressor is preferably more than sufficient for turbine requirements to enable a portion of the compressor delivery to be tapped and passed through a heat exchanger utilising the exhaust heat of the engine whereafter it is

delivered to a turbine which may be arranged to drive means for causing cooling air to flow through the intercooler.

If desired in the channel between the delivery side of the compressor and the intercooler valve means may be provided which are operable to provide a restricted flow path from the compressor to a branch channel through which the air delivered by the compressor is caused to flow so that the compressor does increased work on the air and provides a supply of hot air for heating purposes. The provision of this heating choke renders the apparatus suitable for heating the cabin of an aircraft when the latter is standing at temperatures below freezing point, for example at arctic airfields, or for other space-heating applications, the branch channel being adapted to receive means capable of detachable connection to the aircraft or other structure, as in the case of the delivery side of the expander.

The heating choke may be adjustable to enable the compressor delivery to be variably throttled in order to afford the desired degree of heating. Moreover the valve means may be operated to isolate the expander from the compressor delivery without bringing the heating choke into operation whereby a supply of pressure air at ordinary temperatures is available from the compressor for the purpose of pressure testing the cabin of the aircraft and enabling safety checks to be made on the valves and general airworthiness of the pressure cabin.

If desired, means may also be provided for injecting liquid disinfectant or deodorant material into the air entering the compressor to enable the cabin to be fumigated or deodorised. This anti-pest or deodorant injection is of particular benefit when the aircraft is standing at an aerodrome in the tropics.

In one practical embodiment of the invention the cooling means may constructed as a truck or other vehicle capable of being driven or drawn across the aerodrome to a positon adjacent the cabin of a standing aircraft where it forms a self-contained unit capable of supplying all the aforementioned cabin air-conditioning services. Preferably the truck is constructed as a trailer vehicle provided with wheels or skids, a drawbar being provided to enable the truck to be drawn across the aerodrome to the aircraft by means of a tract or the like. The prime mover is in the form of an internal combustion engine of the piston type mounted on the chassis of the truck with its crankshaft arranged longitudinally thereof, such crankshaft driving through increased speed gearing a centrifugal compressor mounted on a shaft which is also preferably arranged longitudinally of the truck chassis.

Arranged coaxially of the centrifugal compressor and coupled thereto by means of a common shaft is an inward flow turbine, air delivered by the compressor passing along ducting to the turbine over which it is expanded with extraction of heat therefrom. Arranged in the ducting is an air-to-air heat exchanger operating as an intercooler for the throughput air which is accordingly cooled after leaving the compressor and before passing to the turbine where further heat is extracted whereafter it is delivered along a duct forming a cold air delivery pipe. The latter may have coupled to its free end a flexible hose the other end of which is provided with coupling means to enable it to be connected to a nozzle leading to the aircraft cabin.

The truck also carries a fuel supply for the engine so that the vehicle is enabled to operate as a complete self-contained unit, as already mentioned, when it is brought into juxtaposition with the aircraft. In order to enable utilisation of the exhaust heat of the engine the exhaust may be passed to a heat exchanger through which air tapped from the compressor delivery is delivered and thereby heated before delivery to a tubrine. The disc of this exhaust heat turbine is mounted on a shaft which also carries a fan operating to induce atmospheric air through the intercooler arranged between the compressor and turbine of the apparatus. For this purpose the compressor may be made of somewhat larger capacity than is required for cooling air requirements so that the tapping of a portion of its delivery to the exhaust heat exchanger will not reduce the efficiency of the air cycle cooling means.

Air at the ambient temperature of the aerodrome is first drawn through a filter and then a silencer before entering the compressor, a further silencer being preferably arranged immediately after the latter. Between the inlet silencer and the compressor an injection pump is arranged and is capable of pumping disinfectant or deodorant solution into the inlet of the compressor when required as an anti-pest or deodorising measure. From the delivery silencer the compressed air passes along the ducting to the fan-cooled intercooler, which removes at least part of the heat generated due to the compression of the air, and thence to the expansion turbine in which further heat is removed from the air stream which passes therefrom through water separator arranged in the cold air delivery pipe.

From the ducting between the compressor and the intercooler a branch channel leads which is closed when the apparatus is being operated to supply cooling air. This branch channel, and the duct are provided with valve means operable to close the duct to the intercooler and open the branch channel which is provided with adjustable restriction valve means operable to form a choke so that the air delivered from the compressor and passing therealong is heated to form a source of

heated air for cabin-heating purposes when an aircraft is standing on an arctic airfield. As already described in relation to the cooled air supply, the heated air may be supplied to the aircraft cabin through a hosepipe fitted to the end of the branch channel. The same branch channel or a further branch channel on either side of the intercooler may be arranged with suitable valve means to provide a source of pressurising air at moderate temperature to enable safety checks to be made on the valves of the pressure cabins of high altitude aircraft, a pressure relief valve being provided which is set at the rated pressure when pressure testing.

If desired the chassis of the truck may comprise longitudinal members connected by cross members, a body of light sheet metal being provided to enclose the various machines. Preferably the engine, its radiator and the compressor are arranged in an insulated tunnel with the radiator fan drawing air through louvres in the front of the truck body and exhausting at the rear, this arrangement enabling the segragation of these elements in order to prevent undue loss of cooling efficiency through radiation of heat therefrom to the intercooler and expansion turbine.

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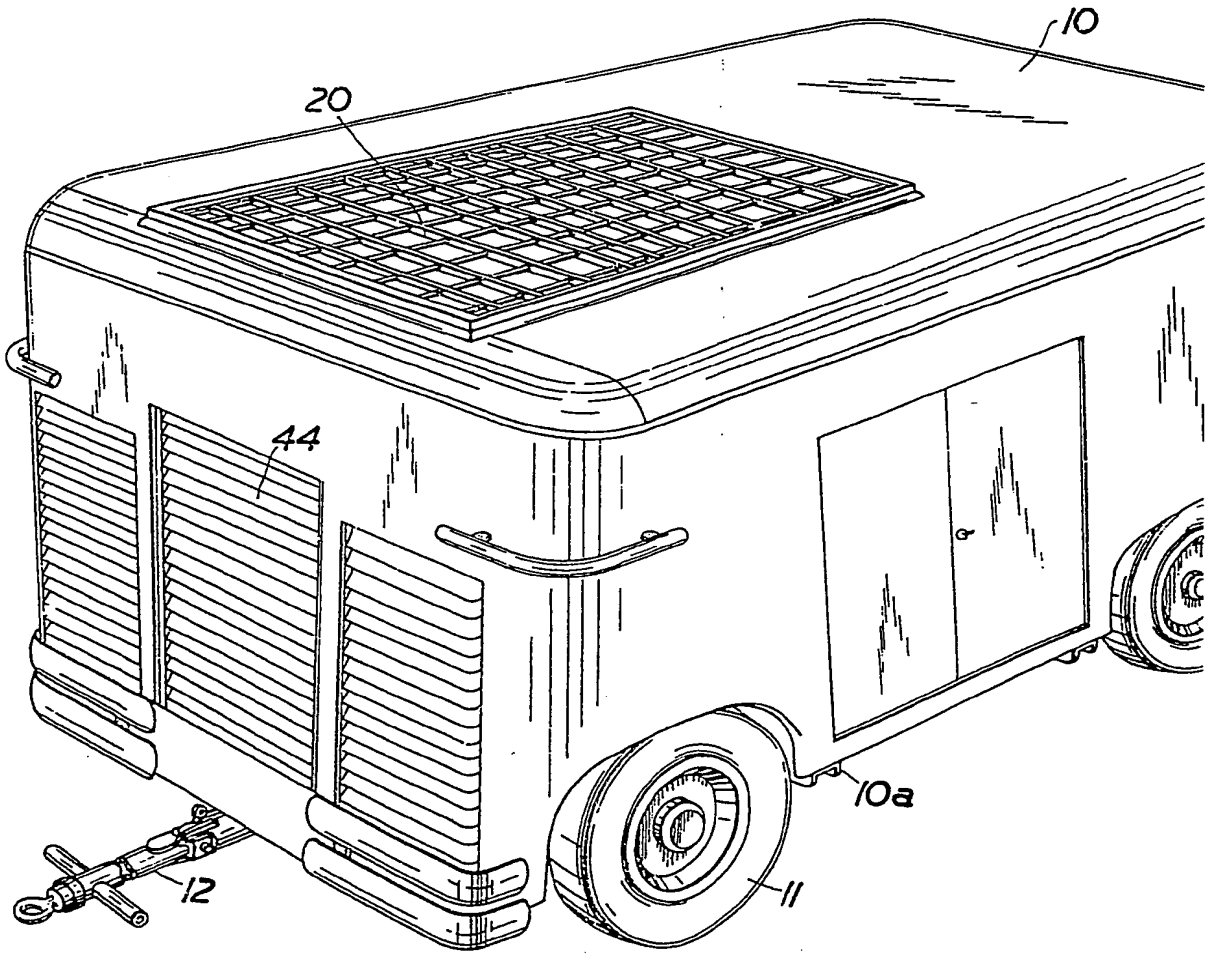

FIG. 1.

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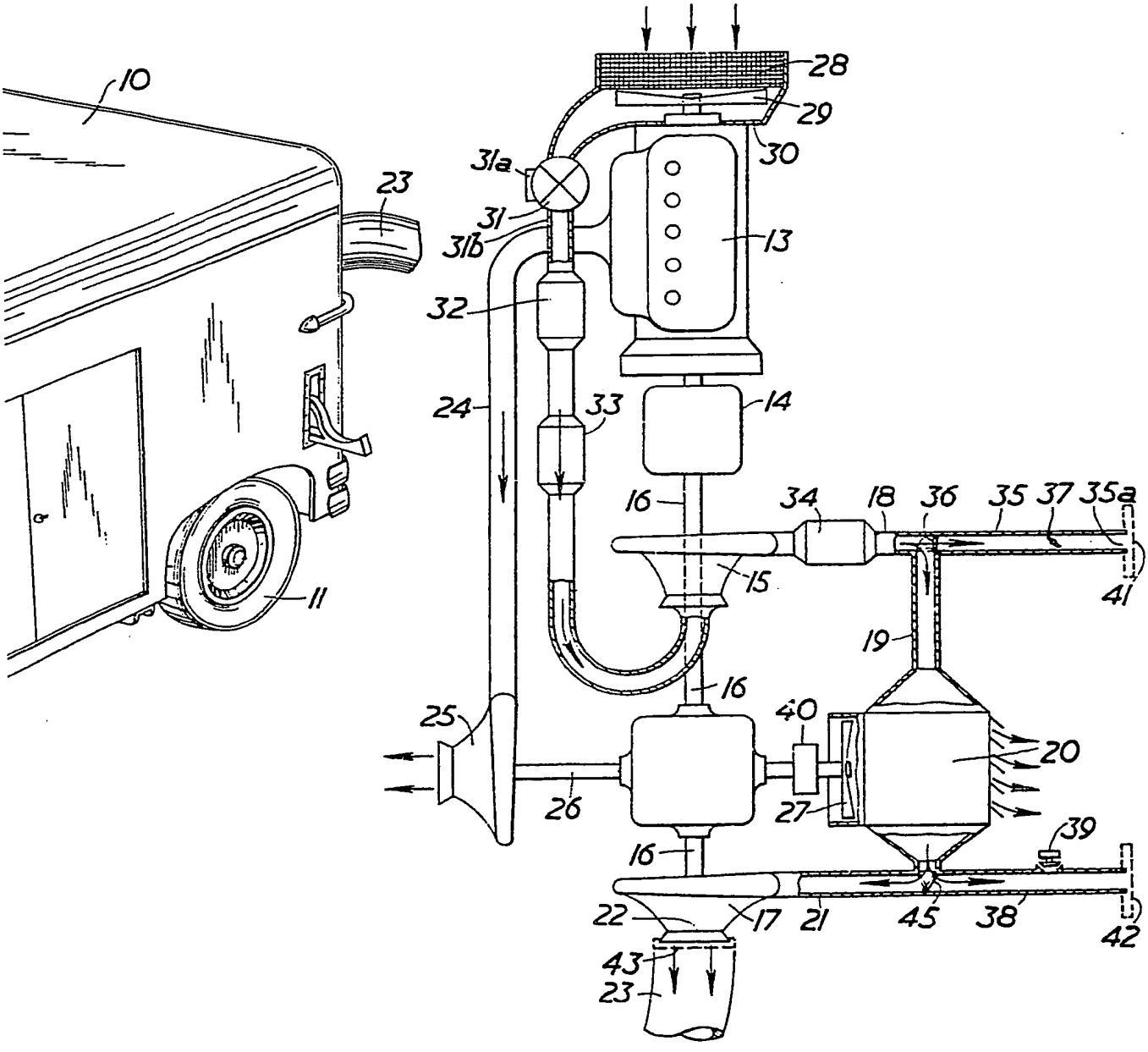

FIG. 2.

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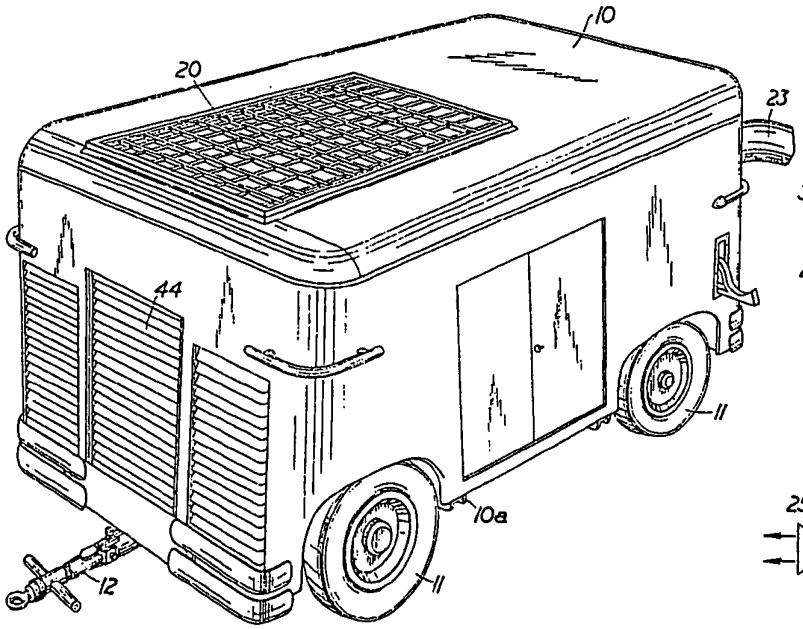

FIG. 1.

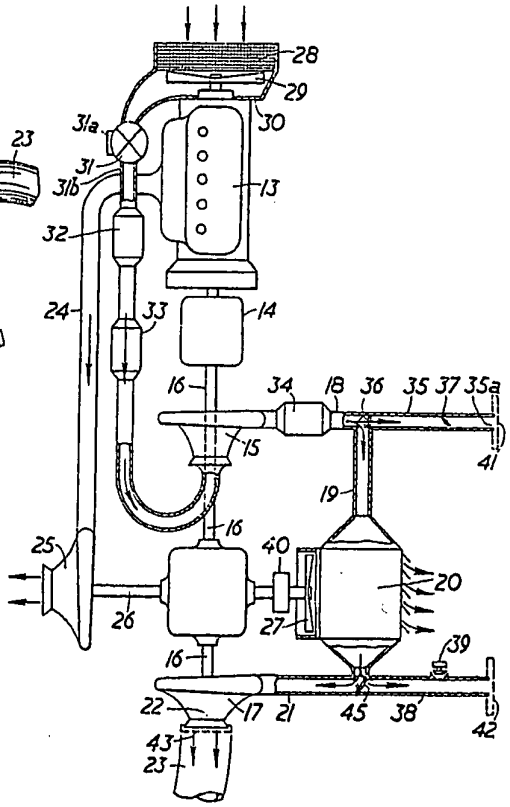

FIG. 2.